MEMORANDUM

TO: SSC

FROM: NGOs

DATE: May 13, 2011

RE: PIPE HARDENING METHODOLOGIES

I. Short Summary - Comparison of Transmission Hardening Methodologies

Methodology	Description		
All	All use soft constrained sensitivity flows, and use four years' worth of data (2020, 2025, 2030, 2035) to smooth out period-to-period bumps. All methods seem to allow for assessing anomalies but no specific protocol other than sub-team review is in place. All methods can produce very large, or very conservative, build outs – depending on the values chosen for the key parameters in each methodology. The three methods tend to show the same or similar needed build outs between specific NEEM regions (i.e., the same lines/connections tend to be expanded in the different methods), but they differ in *how much* these paths will be expended. Except for the Johnson "combined" method, you will get different expansions depending on whether you are using the OL25 or OL75 sensitivity to determine the new pipe sizes. The NGOs recommend looking at the output data from all three methods for futures 2 and 3, asking the NEEM/TX subteam (especially Ruthven/Hadley/Pradip/Johnson/Fagan who came up with the methodologies) to make a recommendation on the specific new pipe sizes between all the NEEM regions, with the SSC ultimately deciding the sizes.		
	Description	**Pros**	**Cons**
Ruthven/Hadley/Pradip	Size new path using "capacity factor" specification (=annual energy utilization of path, which is total MWh flow /	Varying capacity factor specification according to shadow price is a valiant attempt to	Key problem - reads too much into the shadow price data. Also, overly

	total potential MWh flow), in combination with shadow price level. The higher the shadow price, the lower the designated capacity factor. A low capacity factor allows a large[r] path to be built even when used infrequently. Complex use of base pipe flows and overload pipe flows in combination with shadow price to derive final pipe size.	recognize that more congested lines might be expanded even if currently used at their limit only infrequently during high price hours.	complex. Drills down too deeply given the modeling construct. Separates base pipe from overload pipe. Somewhat arbitrary use of capacity factor to specify pipe size.
Johnson	Solely flow based methodology that sizes new pipe based on annual energy utilization of existing pipe. If greater than 90% utilization, then it builds a new path size and uses a 75% capacity factor. I.e., it recognizes that existing pipe is nearing its annual limit, and bumps it up accordingly – and proportionately – to the new flow from the sensitivity run. "Combines" OL25 and OL75 in a technically reasonable/logical way.	Somewhat more simple. Does not use shadow price. "Combine" method leapfrogs over the potential problem of which sensitivity flow to use. Flows themselves contain "value" information as they result from relaxing economic constraints.	As with Ruthven's method, somewhat arbitrary use of capacity factor to specify pipe size. "Combine" method for using data from OL25 and OL75 to choose 1 pipe size is complicated and somewhat arbitrary (lots of moving parts that determine the final build out). Does not factor in shadow prices.
NGO	Solely flow-based. Select pipe size based on the flow needed for all *except* the last X% of hours of the period. X can be, e.g., 5%, 10%, 20%, or even higher (meaning that you build-out to meet the flow needs for 95%, 90% or 80% of the time, respectively).	Simple. Visually intuitive. Flows themselves contain "value" information as they result from relaxing economic constraints. Capacity factor of new pipe is artifact	Somewhat arbitrary use of flow duration curve threshold (X%) to specify pipe size. Choice of flow duration curve threshold is critical decision,

	Recommend 10% if using OL75 data, and 20% if using OL25 data. Large range of potential new sizes depending on cutoff/threshold value chosen.	of method, not a sizing input.	and determines how large the pipe sizes will be. Does not factor in shadow prices.

II. Detailed Summary of Transfer Hardening Methodology Proposed by NGOs:

The NGOs recommend a solely-flow based methodology that calculates a new path size based on the flow duration curve that results from the sensitivity run(s). It selects a new pipe size based on the flow needed for all *except* the last X% of hours of the period. X (cutoff, or threshold value) can be, e.g., 5%, 10%, 20%, or even higher (meaning that you build-out to meet the flow needs for 95%, 90% or 80% of the time, respectively). The NGO's suggest a default value for X of 20% for OL25 flows, and 10% for OL75 flows. If the flows at the cutoff point are less than the current path limit, there is no path size expansion.

The mechanics of the method are as follows:

1. For each of the 101 paths, combine the base flow (MW) and overload flow (MW) values (by year, and by load block), for each of the applicable sensitivity runs - OL25 and OL75 – to develop a "total flow" parameter for each run.

2. Create the total flow duration curve for each path representing all four years of data - 2020, 2025, 2030, 2035 – by combining total flow data from the sensitivity runs and sorting on the flow metric, largest to smallest value (y-axis value). Prior to sorting, retain the "duration" or hourly weight metric for each of these flows to subsequently construct the x-axis duration value.

3. Pick a threshold or x-axis cutoff value (hourly duration percentile – "parameter 1") for each of the OL25 and OL75 sensitivity cases and determine the associated y-axis total flow by moving vertically upward from the x-axis cutoff point to the flow duration curve above.

4. If the associated total flow is lower than the current path limit, then no increase to the pipe size for the path is required.

5. If the associated total flow is higher than the current path limit, then this flow value represents the total MW capacity of the increased path (pipe) size.

6. Screen the results for anomalous conditions. Changes to the new pipe size can be made by either choosing a different cutoff point, or directly specifying a pipe size based on other factors following discussion with the Transmission sub-team.

Pros and cons of this approach are listed in the above summary chart.